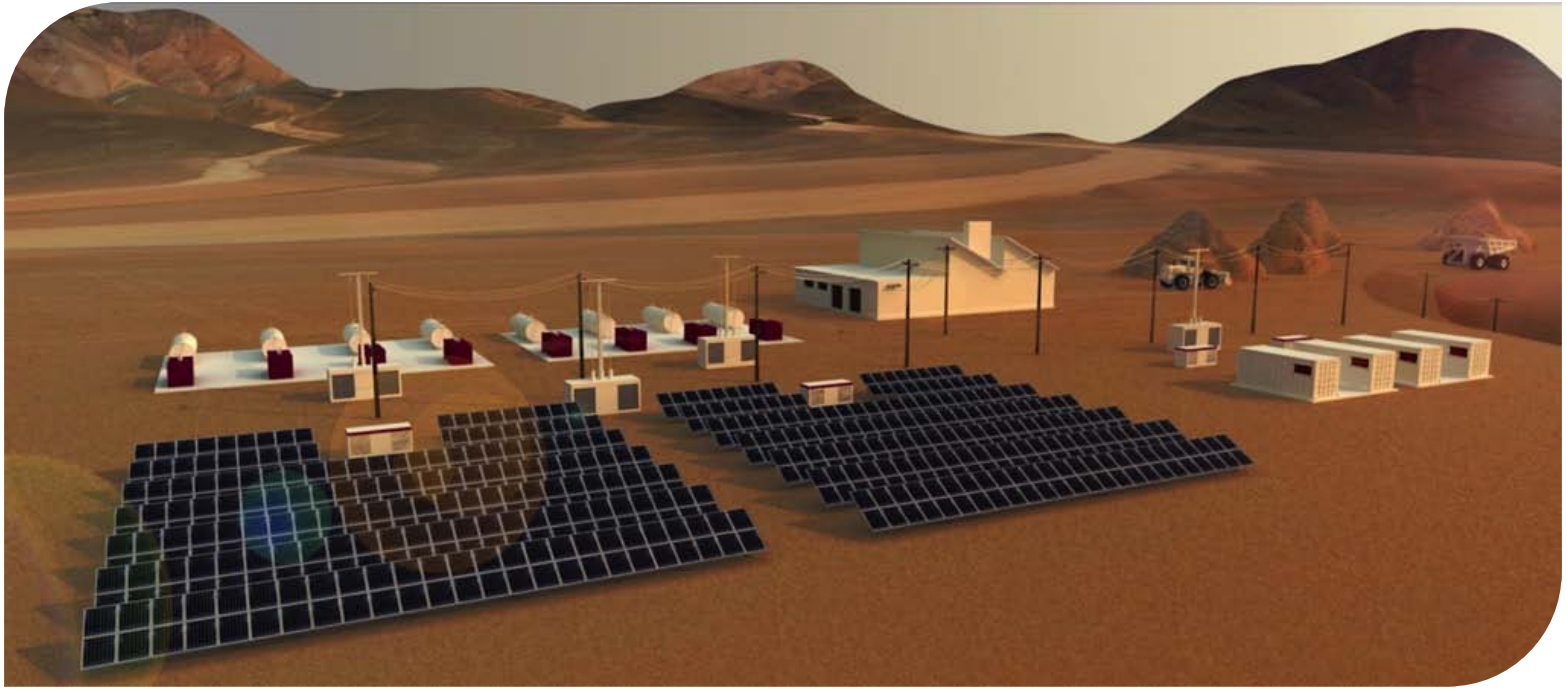
HYBRID SYSTEMS

Solar Energy: A cost advantage for the off-grid mining industry



Xavier Juin · juwi international GmbH

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Juwi at a glance

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Hybrid Systems

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WE MAKE IT HAPPEN

juwi at a Glance

Organisation

- Founded in 1996 by Fred Jung (ju) and Matthias Willenbacher (wi), pioneers for renewable energies with agricultural roots
- juwi AG, not listed on the stock exchange
- 50.1% MVV Energie AG
  49.9% Frema GmbH & Co. KG

Total capacity

Around 3,200 megawatt (approx. 2,350 systems)

Annual energy output

Approx. 6.0 billion kilowatt-hours, corresponds to the annual power demand of around 1.7 million households

Investment volume (since 1996)

> 6.0 billion Euro

Employees & turnover

- Approx. 1,000 employees (worldwide)
- > 700 million Euro in 2013

WE MAKE IT HAPPEN

Our Vision

Our Vision
100% Renewable Energies

Projects

Wind Energy
Solar Energy
on-grid / off-grid

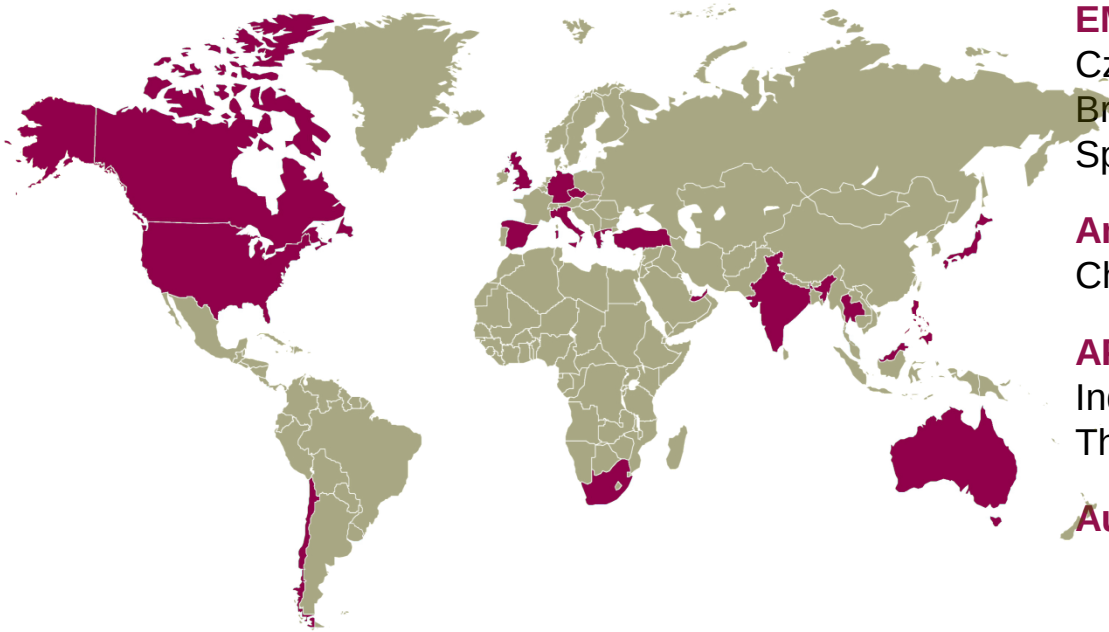
Operations

Technical & Commercial Operations & Maintenance

Our Impetus
Passionately work together to implement renewable energies economically and reliably.

FIGURES AND LOCATIONS

Offices worldwide



EMEA
Czech Republic, Germany, Great Britain, Greece, Italy, South Africa, Spain, Turkey, United Arab Emirates

Americas
Chile, USA/Canada

APAC
India, Japan, Singapore, Philippines, Thailand

Australia

OUR PASSION

Our Business Activities

OUR PASSION

We Construct Your Solar or Wind Power Plant

Wind Energy

- more than 840 wind turbines (at more than 100 locations)
- more than 1.800 MW of installed capacity
- total investment: approx. € 2,4 billion
- annual energy production: approx. 4,6 billion kWh

Plouguin wind farm, Bretagne

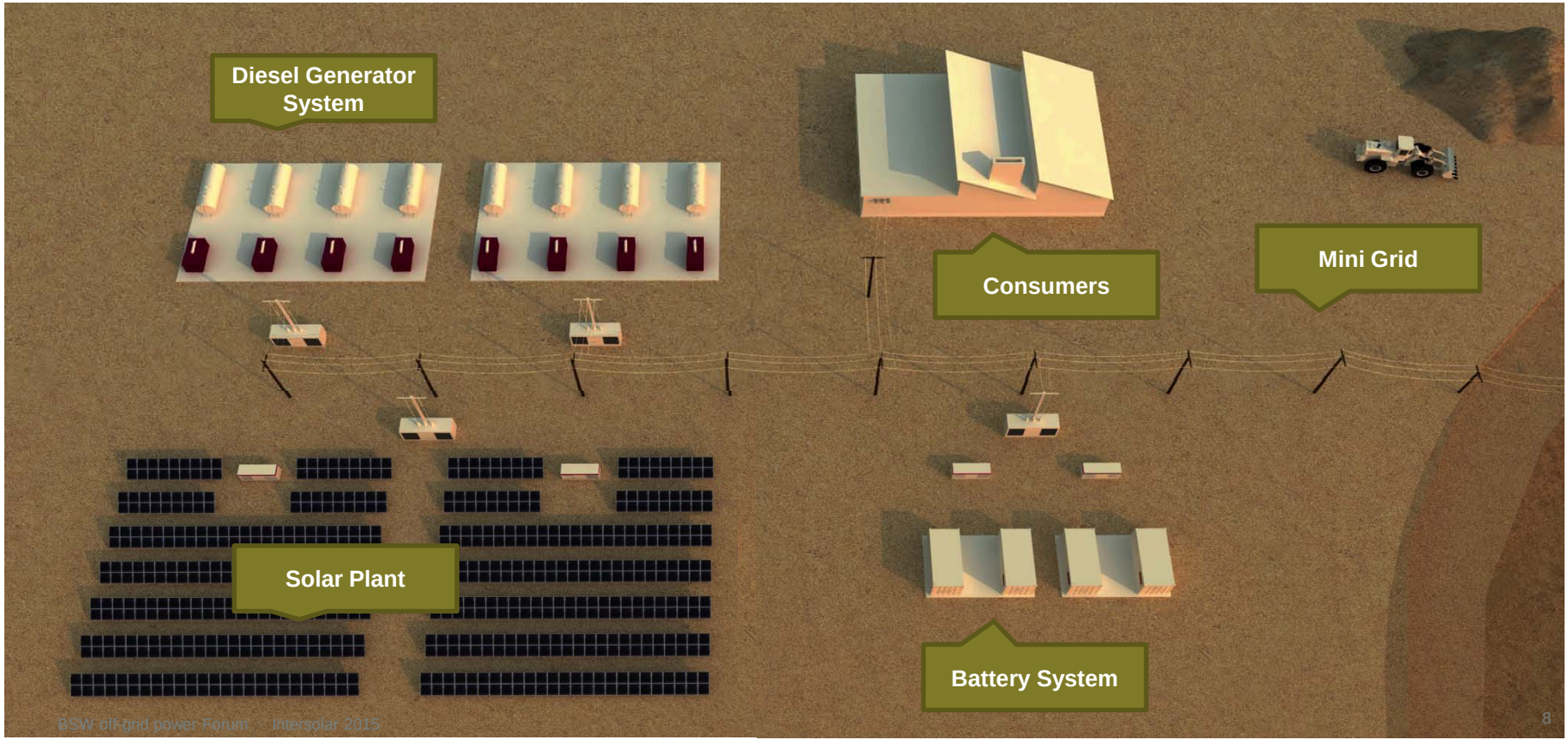
Solar Energy

- more than 1.500 PV installations
- more than 1.400 MW of installed capacity
- total investment: approx. € 3,7 billion
- annual energy production: approx. 1,4 billion kWh

PV-free-field installation Drama, Greece

Hybrid Systems

Industrial application with scalable approach



Hybrid Systems

Why Hybrid Power is economically interesting?

Benefits

- Cost: PV cheaper than diesel generation
- Diesel exposure: reduce impact of diesel price rises
- Carbon emissions: significant reduction
- Technology: simplifying solar/diesel integration
- Public image: enhanced profile

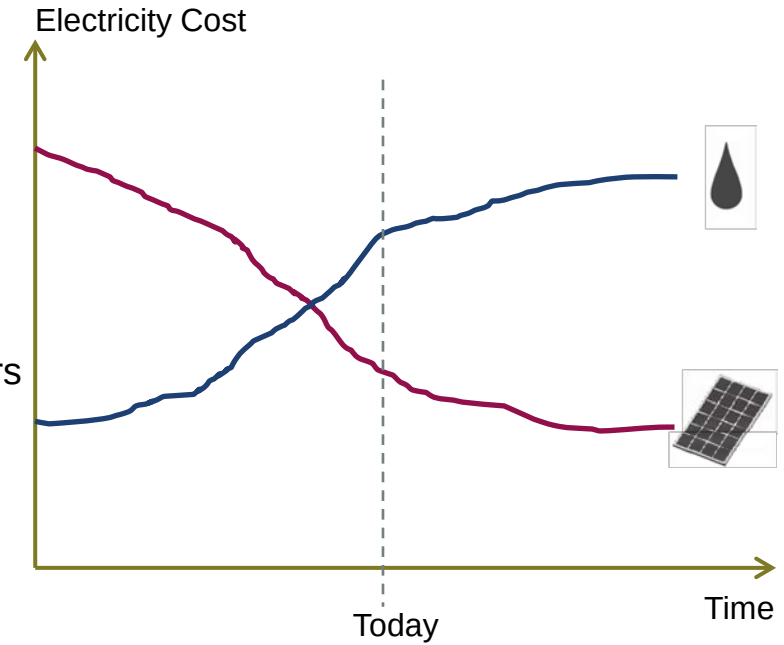
Renewable Energy Trend

- PV and Battery prices decreased > 50% in the last years
- PV and Battery prices keep decreasing

Fossil Fuel Trend

- Diesel & Gas: increasing with higher volatility

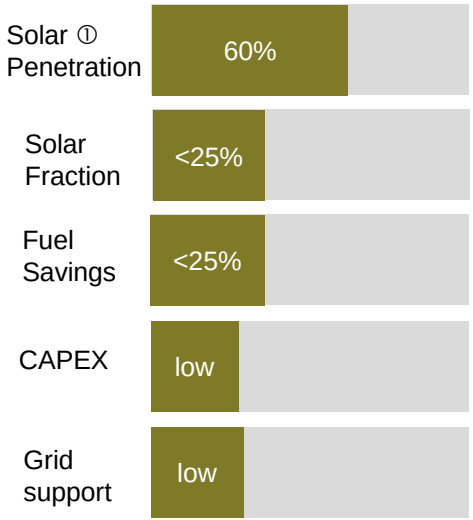
PV vs Diesel Cost



Hybrid Systems

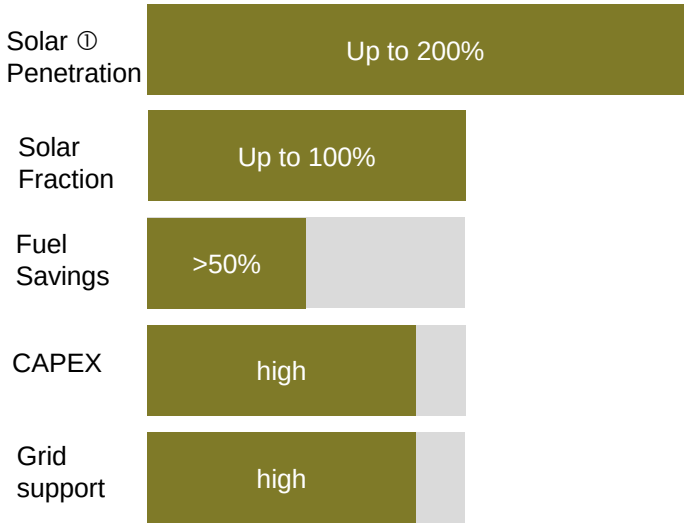
Comparison of Solar Penetration

Low Penetration Applications



- Generator leading system
- Simple control mechanism
- No BESS necessary
- Brownfield

High Penetration Applications



- Battery or generator leading system
- Complex control mechanism
- BESS necessary
- Diesel off-mode possible

① Power ratio P_{PV}/P_{Gen}

Sandfire Project, Australia

Current Situation

Degrussa Mine:

- **Mining:** Gold and copper
- **Location:** Doolgunna Region, North-Western Australia
- **Customer:** Sandfire Resources NL
- **Distance:** ~1000 km to Perth

Power Supply:

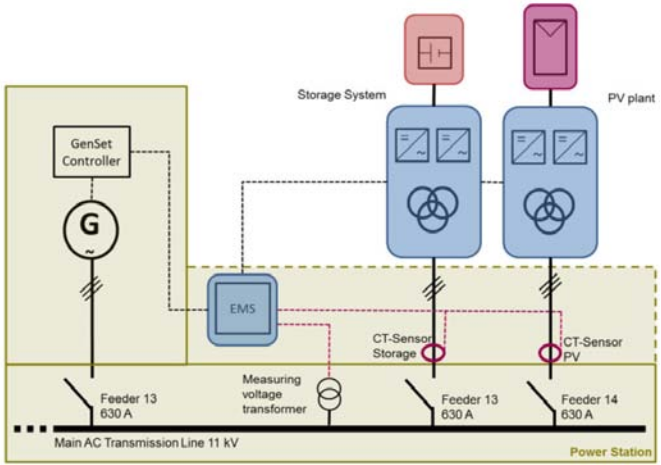
- **Diesel Power Station:** ~ 20MW
- **Operator:** 3rd party power station owner
- **Average load:** ~ 11MW
- **Average consumption:** ~ 100GWh p.a.

Sandfire Project, Australia

System Design

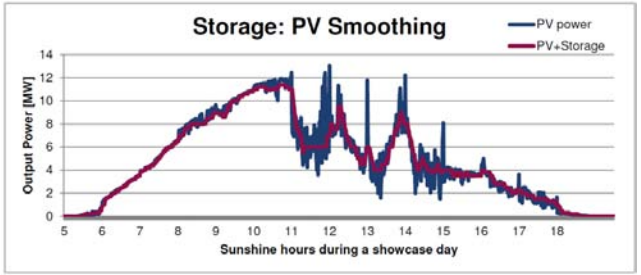
Hybrid Power Plant:

- **PV-Modules:** 10,565 MWp
- **Tracking:** East-West tracking
- **PV-Inverter:** 10 MW
- **Storage:** 4 MW / 1,8 MWh (6 MW peak)
- **Operator:** juwi Australia



Storage tasks:

- Provide spinning reserve to switch of gen-sets
- Control ramp rate → PV smoothing
- Additional spinning reserve at night
- Provide frequency support and power factor >0,8
- Grid forming if diesel-off mode (during low load days)



Sandfire Project, Australia

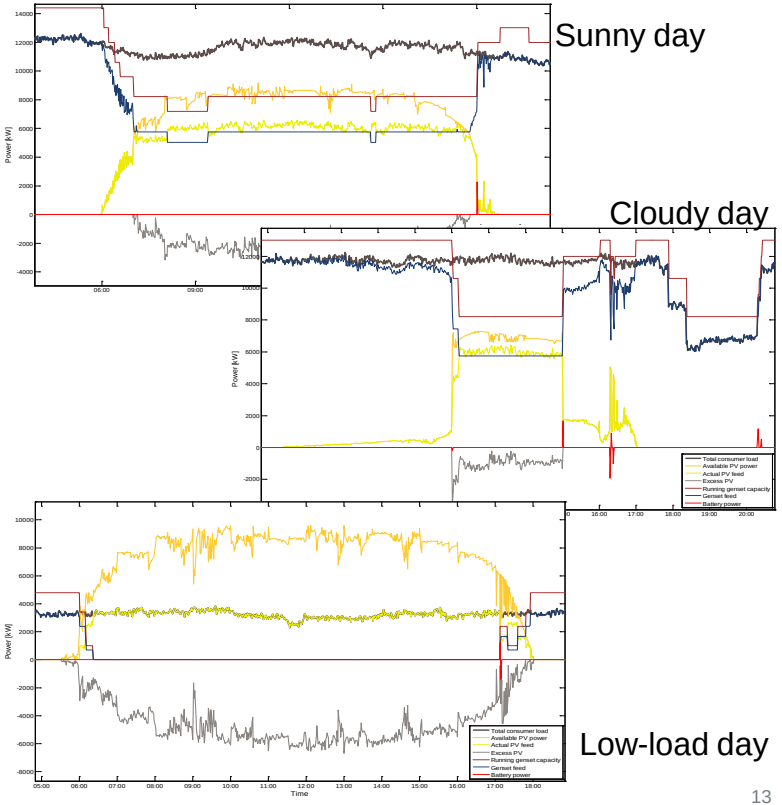
Simulation Results

Simulations:

- Energy study: full year on minute basis with Homer Pro 3.2 and PV Hyb 2.2
- Grid stability with PowerFactory
- Storage Lifetime Simulation from manufacturer

Results:

- **Electricity from PV:** 21.1 GWh
- **Curtailment:** ~ 5 %
- **Diesel Savings:** 6 million litres (~ 25% of total consumption)
- **CO_2 Savings:** 12,938 tonnes



Sandfire Project, Australia

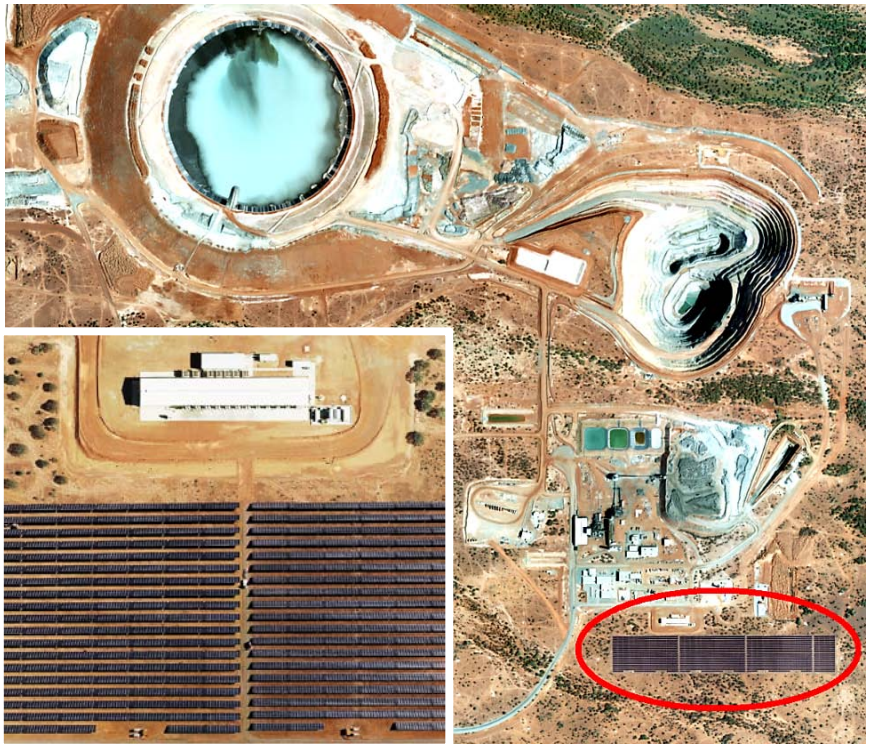
Summary and Outlook

Hybrid Power Plant

- Worldwide biggest combination of an off-grid, high capacity PV system integrated with a diesel power station
- 10,6 MWp PV + 6 MW Storage
- Reducing running Diesel capacity to minimum
- Diesel-off mode during low-load days
- Timeline: project start in mid 2015
  commissioning in early 2016

Main benefits:

- Reduced operation costs (~ 25% diesel savings)
- Possibility of running solar pure mode



Thanks For Your Attention.

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Back up : Hybrid Systems
Simulation Tool

juwi PV Hyb 2.2:

- Input of Load and Solar data (1min – 1h)
- Simulation of Fuel Save, Off-Grid, Own-consumption and Storage Applications
- Detailed financial analysis including sensitivity analysis
- Comparison of different system sizes to choose optimal system
- Export plots showing overview of several days or details of specific periods
- Export function of generated data for further analysis or processing